FRED Reports

Hidden Lake Sockeye Salmon
Investigations, 1983-1984

by
David S. Litchfield and
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Number 86

Alaska Department of Fish & Game
Division of Fisheries Rehabilitation,
Enhancement and Development

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July 1988

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ABSTRACT

The Hidden Lake smolt migration was 235,200 (±2,700) sockeye salmon, *Oncorhynchus nerka*, and 23,100 (±200) coho salmon, *O. kisutch*, for 1983, and 419,800 (±2,500) sockeye salmon and 32,000 (±200) coho salmon for 1984. The hatchery contribution for 1984 was estimated at 243,500 (±35,500; 95% CI) or approximately 61% of the estimated age-1.0 migration. The estimated survival rate to smolts of the 1985 released fingerlings[1] is 22.4%. The 1983 and 1984 adult sockeye salmon escapements were 11,297 and 27,832, respectively. The 1984 adult sockeye salmon escapement was the highest recorded for the Hidden Lake system.

KEY WORDS: Sockeye salmon, *Oncorhynchus nerka*, salmon enhancement, infectious hematopoietic necrosis (IHN) virus.

INTRODUCTION

Initial studies of biological and physical inventories of the Cook Inlet watershed began in 1972 and 1973 (Bill et al. 1972; Barton and Barrett 1973). These studies indicated that Hidden Lake had the highest potential for increased salmon production of any of the lake systems studied. As a result, Hidden Lake was selected by the Alaska Department of Fish and Game (ADF&G), Fisheries Rehabilitation, Enhancement and Development (FRED) Division as an enhancement site in 1976. During the first year, baseline information of physical, chemical, and biological parameters was collected for assessing the impact of planned

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[1] Fingerlings are those juveniles that have doubled or nearly doubled their weight after emergence.

enhancement. In the fall of 1976, the first adult sockeye salmon, *Oncorhynchus nerka*, were captured for egg collection. In the spring of 1977, fingerlings were released back into the lake. Since 1976, smolt and adult inventories and limnology studies have been conducted at Hidden Lake annually (Kyle 1977, 1979a; Litchfield 1983; Litchfield and Todd 1983). Hatchery-reared fingerlings were released at Hidden Lake in the spring of 1977, 1978, 1979, 1983, and 1984.

Hidden Lake is an oligotrophic-mesotrophic clear-water system (Jeff Koenings, pers. comm.) located in the foothills of the Kenai Mountains and within the Kenai Wildlife Refuge; it is 69 km (43 miles) east of the City of Soldotna. Access to Hidden Lake is provided by the Skilak Loop Road (Figure 1).

The known sockeye salmon spawning areas are located at the western end of the lake; minimal spawning occurs at the eastern end because of a steep, rocky shoreline (Figure 2). All returning adult sockeye salmon are shoreline spawners. Numerous small intermittent inlets do not provide any spawning areas because of either poor flows or unsuitable substrate. Hidden Creek (outlet creek) has suitable spawning habitat in some of its 4.7-km (2.9 miles) length; however, this area is utilized by coho salmon, *O. kisutch*, spawners. The main reason for the low level of sockeye salmon production in Hidden Lake is believed to be due to limited spawning area; lake limnology studies indicate a much greater rearing potential. Further information can be found in annual progress reports from 1976 to 1982 (Kyle 1977, 1979a, 1979b; Kyle et al. 1980; Litchfield 1983; Litchfield and Todd 1983).

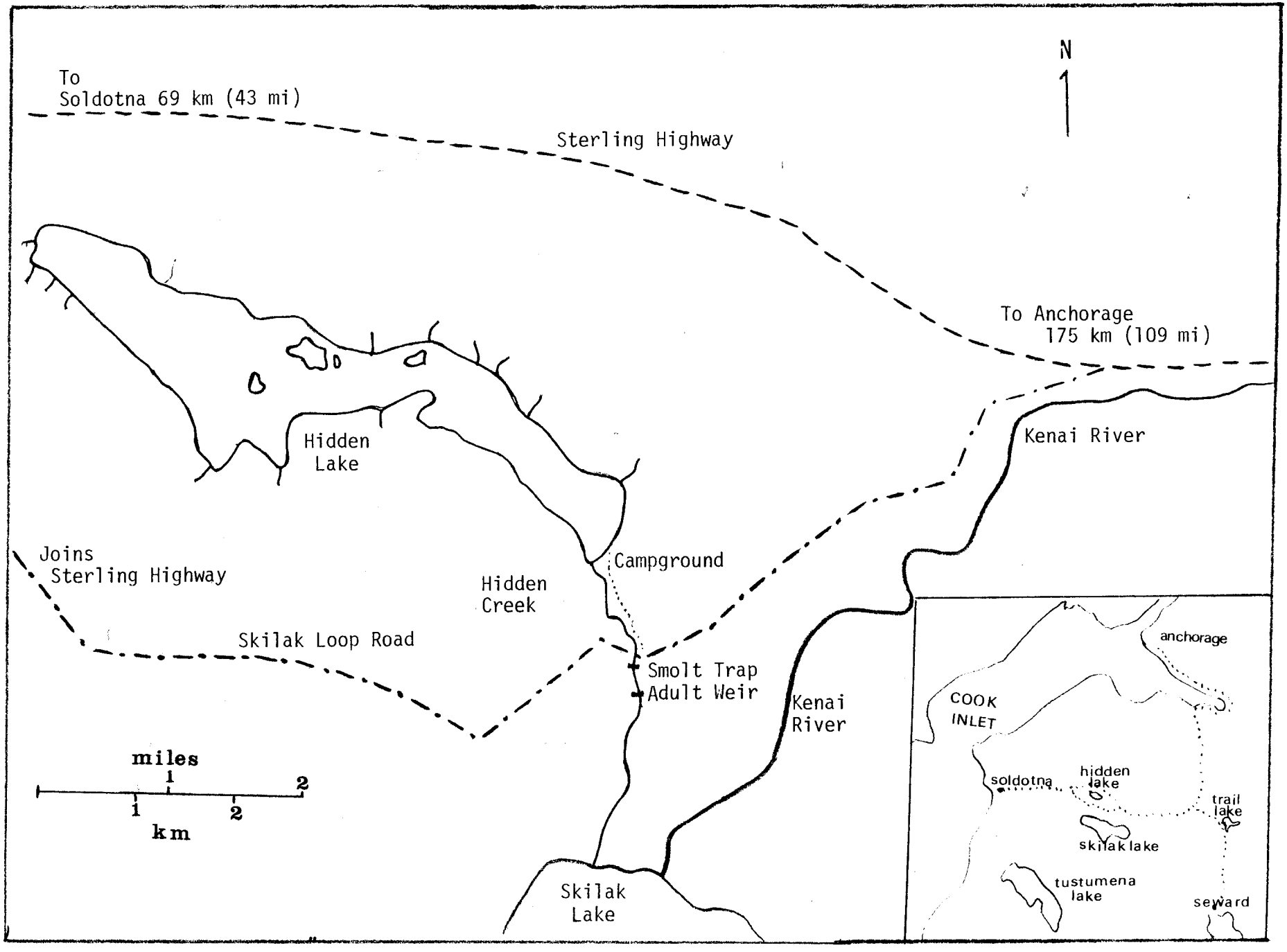
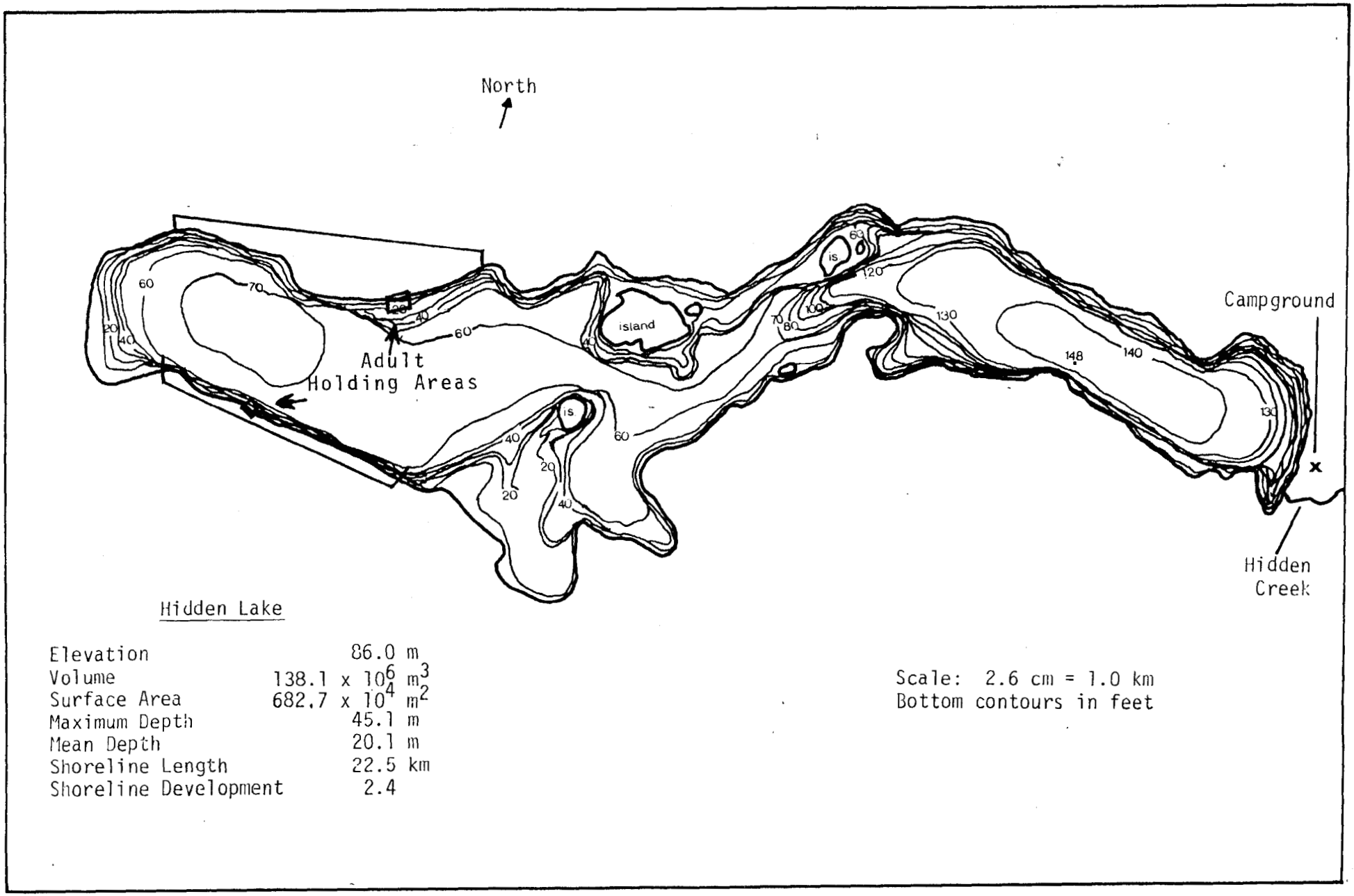


Figure 1. Location of Hidden Lake, Hidden Creek, and adult and smolt sampling sites on Hidden Creek (not to scale).



Hidden Lake

Elevation	86.0 m
Volume	138.1 x 10^6 m^3
Surface Area	682.7 x 10^4 m^2
Maximum Depth	45.1 m
Mean Depth	20.1 m
Shoreline Length	22.5 km
Shoreline Development	2.4

Scale: 2.6 cm = 1.0 km
Bottom contours in feet

Figure 2. Bathymetric map of Hidden Lake showing major adult sockeye salmon spawning and holding areas.

MATERIALS AND METHODS

Smolt Migration

A smolt fyke net was installed in Hidden Creek on 23 May 1983 and on 22 May 1984 in the location used in previous years (*see* Figure 1). A Bendix sonar counter and divided livebox were attached to the fyke net for enumerating smolts (Figure 3).

Smolts were counted by three methods: (1) in the sonar-counter method smolts passed through a 44- x 10-cm opening where two pairs of opposing transducers were mounted; (2) in the individual-count method all smolts were diverted into one livebox and counted; and (3) in the subsampling method 3-min smolt counts occurred three times per hour. The sonar counters were not operative during the outmigration. The individual counts were used during times of low migration rates (nonpeak times), and the subsampling periods were used when large numbers of migrants were passing or the sonar counter was not functioning.

Subsampling counts were averaged and multiplied by 20 to estimate the number of smolts passed per hour. The hourly estimate is

$$h = \left(\sum_{i=1}^{3} Ci/3\right) \cdot 20,$$

and the variance of the hourly estimate is

$$S_h^2 = \frac{\sum_{i=1}^{3} (Ci - h)^2}{2 \cdot 3} (20)^2$$

Where Ci = the ith sample count, and
h = the hourly estimate.

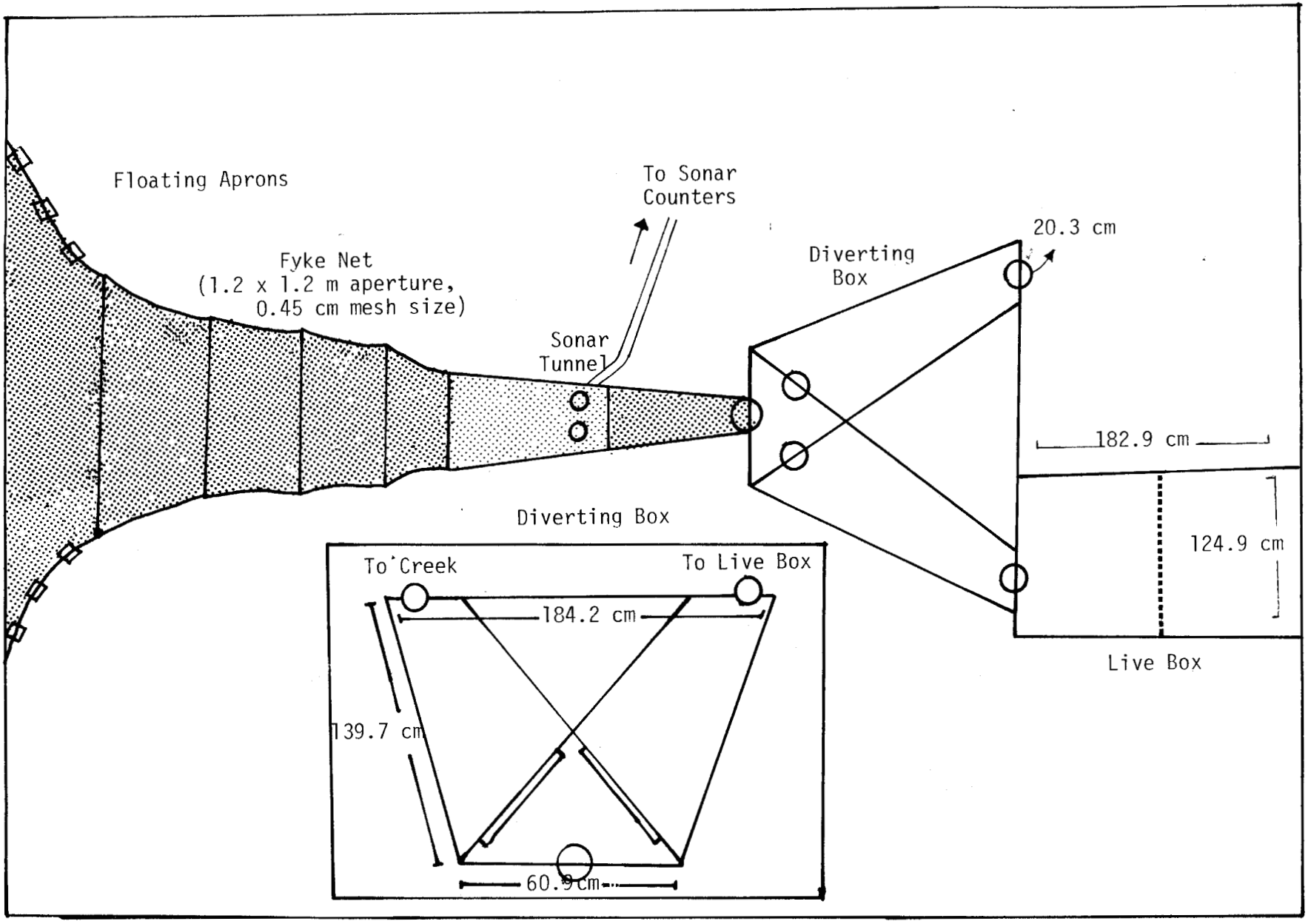


Figure 3. Schematic diagram of Hidden Lake smolt fyke net, diverting box, and sonar counter (not to scale).

Variances for the sums of hourly estimates were obtained by summing the individual variances.

Each day 30 randomly selected sockeye salmon and 20 coho salmon smolts were netted, anesthetized with MS222 (tricaine methanesulfonate), and sampled for weight (g) and fork length (mm); scales were also taken for age determination. Weights, lengths, and age-class composition were weighted over the migration period by 5-day intervals (Cochran 1963).

Adult Escapement

A double-V-shaped portable picket weir was installed on 11 July 1983 and 29 June 1984 at the same location used in previous years (*see* Figure 1). Each day 30 randomly selected adult sockeye salmon were weighed to the nearest 0.1 kg, measured (mideye to fork of tail) to the nearest millimeter, and sampled for age determination. Age was determined by placing three scales on a gummed card and later pressing them onto acetate cards for viewing under a microfiche reader. Adults were captured for sampling by netting them between the two weir panels, which were approximately 6 m (20 ft) apart. Adults were counted and passed twice daily. Fish were allowed to pass through the weir by removing a picket from both the downstream and upstream panels.

Spawning Operations

A large adult-holding area that was 7.6 x 22.9 m (25 x 75 ft) was constructed on the southwest side of the lake in early September 1983 and on the northwest side of the lake in 1984 (*see* Figure 2).

Sockeye salmon adults were captured on littoral spawning grounds with a 60.9- x 3.0-m adult seine (3.2-cm mesh). Adults that were captured away from the location of the holding areas were transported by boat in a 112.9- x 122- x 5.9-cm tote. An adult trap

net was also used in 1984, but because of mortality problems, it was discontinued. When adequate numbers of female salmon were confirmed for ripeness, a spawning operation was conducted. Because of a positive disease history, individual female eggs were placed in separate containers and sent to the Trail Lakes Hatchery where they were fertilized with sperm from two males and disinfected before being placed in incubation trays. The isolation of egg families allows healthy eggs, alevins, or fry to be saved and those with disease to be readily disposed.

Fingerling Releases

In 1983 two 700-liter (185 gal) oxygenated tanks were used to transport fingerlings from the hatchery to a release site at the lake. In 1984 a large 1,893-liter (500 gal) supply tank was used. Fingerlings were released directly into the lake from a delivery vehicle through a 15.3-m x 7.6-cm flexible hose.

Pathology Sampling

Samples of sockeye salmon smolts and adults were collected to screen for infectious hematopoietic necrosis (IHN) in 1983 and 1984. During the spring of 1983 and 1984, 94 and 47 samples of dead and dying smolts were collected, respectively; they were frozen for later examination. In addition, a sample of 181 normal-appearing smolts was collected in 1984 to document IHN incidence. During the fall of 1983 and 1984, approximately 60 post-spawned female adults were captured and screened for IHN virus by collecting samples of ovarian fluid.[2]

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[2] Collection and analysis procedures can be obtained through the ADF&G Fish Pathology Laboratory, Anchorage, Alaska.

RESULTS

Smolt Migration

The total smolt migration estimates were 235,200 (±2,700) sockeye salmon and 23,100 (±200) coho salmon in 1983, and 419,800 (±2,500) sockeye salmon and 32,000 (±200) coho salmon in 1984 (95% CI). The 1984 coho salmon smolt migration was the highest recorded for the system.

In 1983 the peak migration period occurred from 6 to 18 June; an estimated 83,400 (±2,700; 35.4% of total) sockeye salmon smolts migrated. In 1984 the peak movement occurred from 3 to 25 June; an estimated 176,900 (±300; 41.2% of total) migrated. The sonar equipment was not used in 1983 and 1984 because of mechanical problems.

The smolt-migration timing for 1983 and 1984 was very similar in that the majority of older and larger age-2.0 sockeye salmon smolts left the system during the early part of the run. The onset and termination of migration was also similar; however, in 1984 the peak (17 June) was 9 days later than the one (8 June) in 1983 (Table 1).

In 1983 and 1984, 93.4% and 94.9% of the sockeye salmon smolts were age 1.0, and 60.0% and 66.4% of the coho salmon smolts were age 2.0, respectively. The average length and weight of sampled age-1.0 sockeye salmon smolts, however, were 11.7 mm and 7.4 g less in 1983 than in 1984, even though fewer fish emigrated in 1983 (Table 2). The sampled 1984 hatchery and wild-stock sockeye salmon smolts were not significantly different ($P>.05$) in length and weight.

Table 1. Sockeye and coho salmon smolts daily migration in Hidden Creek, 1983 and 1984.

	1983				1984			
	Sockeye		Coho		Sockeye		Coho	
Date	Daily number passed	Accumulative total	Daily number passed	Accumulative total	Daily number passed	Accumulative total	Daily number passed	Accumulative total
5/22	N.D.	N.D.	N.D.	N.D.	2	2	61	61
5/23	0	0	3	3	32	34	75	136
5/24	0	0	1	4	197	231	98	234
5/25	39	39	3	7	323	554	473	707
5/26	123	162	7	14	278	832	410	1,117
5/27	6	168	4	18	356	1,188	444	1,561
5/28	45	213	32	50	744	1,932	911	2,472
5/29	11	224	71	121	2,115	4,047	1,234	3,706
5/30	50	274	80	201	1,965	6,012	1,928	5,634
5/31	129	403	172	373	3,818	9,830	1,962	7,596
6/01	49	452	418	791	4,800	14,430	1,977	9,573
6/02	1,207	1,695	711	1,502	10,377	24,807	1,788	11,361
6/03	532	2,191	746	2,248	11,439	36,246	2,234	13,595
6/04	5,266	7,457	792	3,040	10,989	47,235	2,161	15,756
6/05	7,654	15,111	1,135	4,175	22,664	69,899	2,484	18,240
6/06	22,159	37,270	2,045	6,220	12,723	82,622	1,271	19,511
6/07	12,471	49,741	1,763	7,983	9,133	91,755	1,523	21,034
6/08	24,239	73,980	2,027	10,010	18,011	109,766	834	32,868
6/09	16,939	90,919	2,365	12,375	29,197	138,963	1,406	23,274
6/10	22,480	113,399	2,418	14,793	16,287	155,250	1,028	24,302
6/11	8,226	121,625	1,016	15,809	23,459	178,709	751	25,053
6/12	7,619	129,244	698	16,507	12,781	191,490	669	25,722
6/13	5,557	134,801	928	17,435	8,330	199,820	993	26,715
6/14	10,555	145,356	661	18,096	8,528	208,348	774	27,489
6/15	17,180	162,536	801	18,897	20,735	229,083	646	28,135
6/16	10,938	173,474	858	19,755	31,200	260,283	810	28,945
6/17	15,918	189,392	753	20,508	31,669	291,952	984	29,929
6/18	6,076	195,468	874	21,382	27,317	319,269	495	30,424
6/19	4,613	200,081	358	21,740	16,655	335,924	160	30,584

-continued-

Table 1 continued. Sockeye and coho salmon smolts daily migration in Hidden Creek, 1983 and 1984.

	1983				1984			
	Sockeye		Coho		Sockeye		Coho	
Date	Daily number passed	Accumulative total	Daily number passed	Accumulative total	Daily number passed	Accumulative total	Daily number passed	Accumulative total
6/20	3,557	203,638	198	21,938	11,328	347,252	137	30,721
6/21	2,005	205,643	277	22,215	7,885	355,137	156	30,877
6/22	1,934	207,577	219	22,434	8,911	364,048	69	30,946
6/23	2,267	209,844	134	22,568	7,333	371,381	125	31,071
6/24	2,078	211,922	66	22,634	5,981	377,362	76	31,147
6/25	2,094	214,016	50	22,684	2,555	379,917	43	31,190
6/26	1,205	215,221	43	22,727	3,044	282,961	50	31,240
6/27	2,080	217,301	76	22,803	5,728	388,689	85	31,325
6/28	1,674	218,975	98	22,901	4,436	393,125	24	31,349
6/29	2,309	221,884	59	22,960	2,434	395,559	62	31,411
6/30	2,235	223,520	33	22,993	3,561	399,120	63	31,474
7/01	936	224,456	13	23,006	2,408	401,528	20	31,494
7/02	1,329	225,785	6	23,012	3,447	404,975	27	31,521
7/03	2,774	228,559	5	23,017	2,135	407,110	39	31,560
7/04	2,056	230,615	10	23,027	452	407,562	31	31,591
7/05	721	231,336	10	23,037	50	407,612	1	31,592
7/06	1,238	232,574	17	23,054	1,865	409,477	45	31,636
7/07	696	233,270	3	23,057	2,695	412,172	40	31,676
7/08	391	233,661	3	23,060	913	413,085	13	31,689
7/09	272	233,933	5	23,065	395	413,480	4	31,693
7/10	355	234,288	5	23,070	1,583	415,063	38	31,731
7/11	249	234,537	4	23,074	2,035	417,098	37	31,768
7/12	153	324,690	2	23,076	1,241	418,339	52	31,820
7/13	332	235,022	2	23,078	726	419,065	62	31,882
7/14	211	235,233	1	23,079	300	419,365	38	31,920
7/15					432	419,797	57	31,977

Table 2. Age composition and mean weights and lengths of Hidden Creek sockeye and coho salmon smolts, 1983 and 1984.

Species	Age class	Number sampled	Age composition (%)	Mean length (mm)	SE	Mean weight (g)	SE
			1983				
Sockeye	1	264	93.4	132.0	0.6	21.3	0.3
	2	78	6.6	185.5	6.2	66.1	7.1
Coho	1	5	0.9	109.2	9.2	13.2	3.1
	2	204	60.0	139.6	0.6	24.7	0.2
	3	90	38.4	141.2	0.9	26.1	0.3
	4	1	0.7	150.0	-	33.2	
			1984				
Sockeye	1	551	94.9	143.7	0.3	28.7	0.2
	2	58	5.0	169.6	3.0	49.2	2.6
	3	2	0.1				
Hatchery Sockeye	1	245	100.0	142.9	0.4	28.2	0.3
Coho	1	61	6.5	114.3	1.7	15.1	0.6
	2	307	66.4	137.5	0.8	25.0	0.5
	3	97	27.1	145.9	1.0	28.6	0.6

Hatchery Contribution and Survival

The hatchery contribution estimate for age-1.0 sockeye salmon smolts migrating in 1984 is 243,500 (±35,500; 95% CI), or approximately 61% of the estimated age-1.0 migration. The estimated survival rate of fingerlings to age-1.0 smolts from the 1983 release is 22.4%, which is the highest from any Hidden Lake fingerling release to date.

Adult Escapement

The sockeye salmon escapements were 11,297 from 21 July to 19 August 1983 and 27,832 from 16 July to 15 August 1984. These figures are both higher than the average escapement (9,929) to Hidden Lake from 1976 to 1982 (Appendix Table A). The 1984 escapement is the highest ever recorded. Approximately 40% of the adult escapement was passed during the first week of sampling. The remainder of the escapement was evenly distributed throughout the rest of the sampling period (Table 3). No other species of adult salmon were passed. Age-composition, weight, and length data are presented in Table 4.

Spawning Operations

From 19 September to 6 October 1983, 1.9 million sockeye salmon eggs were collected during 6 separate spawning days. Eggs from 639 female salmon were taken: an average fecundity of 3,017 eggs/female.

From 19 September to 18 October 1984, spawn was taken on eight separate days; 3.8 million eggs were collected from 1,310 female salmon. Average fecundity was 2,875 eggs/female (Table 5). More eggs were taken in 1984 than any other year. The average number of eggs collected annually since 1976 is 1,453,000 (Appendix Table B).

Table 3. Hidden Lake adult sockeye salmon escapement, 1983 and 1984.

1983			1984		
Date	Daily sockeye	Accumulative sockeye	Date	Daily sockeye	Accumulative sockeye
07/21	224	224	07/16	39	39
07/22	595	819	07/17	3,088	3,127
07/23	729	1,548	07/18	1,128	4,255
07/24	1,290	2,838	07/19	921	5,176
07/25	378	3,216	07/20	131	5,307
07/26	712	3,928	07/21	605	5,915
07/27	720	4,648	07/22	5,401	11,313
07/28	167	4,815	07/23	2,462	13,775
07/29	32	4,847	07/24	380	14,155
07/30	858	5,705	07/25	940	15,095
07/31	10	5,715	07/26	1,069	16,164
08/01	165	5,880	07/27	35	16,199
08/02	11	5,891	07/28	2,834	19,033
08/03	70	5,961	07/29	1,275	20,308
08/04	34	5,995	07/30	415	20,723
08/05	292	6,287	07/31	1,717	22,440
08/06	1,120	7,407	08/01	455	22,895
08/07	611	8,018	08/02	40	22,935
08/08	656	8,664	08/03	1,073	24,008
08/09	62	8,726	08/04	49	24,057
08/10	459	9,185	08/05	0	24,057
08/11	406	9,591	08/06	365	24,422
08/12	122	9,713	08/07	733	25,155
08/13	204	9,017	08/08	590	25,745
08/14	429	10,346	08/09	40	25,785
08/15	177	10,523	08/10	722	26,507
08/16	25	10,548	08/11	424	26,931
08/17	101	10,649	08/12	272	27,203
08/18	72	10,721	08/13	181	27,384
08/19	576	11,297	08/14	293	27,677
			08/15	155	27,832

Table 4. Age composition and mean weights and lengths[a/] of Hidden Lake adult sockeye salmon, 1983 and 1984.

Age	Number in sample	Age composition (%)	Mean length (cm)	S.D.	Mean weight (kg)	S.D.
			1983			
1.2(42)	170	86.7	52.9	2.4	2.0	0.3
1.3(52)	21	10.7	55.2	2.6	2.3	0.4
2.2(53)	5	2.6	53.4	2.0	2.0	0.3
			1984			
1.1(32)	1	0.1	45.5	-	1.5	
1.2(42)	659	94.7	52.1	2.0	2.0	0.3
1.3(52)	18	1.4	57.0	2.6	2.7	0.4
2.1(43)	2	0.5	45.2	1.8	1.4	0.1
2.2(53)	34	3.2	54.5	2.3	2.4	0.4
2.3(63)	1	0.1	57.0	-	2.6	

[a/] Lengths are from mideye to fork of tail.

Table 5. The number of sockeye salmon eggs collected at Hidden Lake in 1983 and 1984.

Date	Number of females	Number of eggs
	1983	
09/19	48	142,000
09/22	84	253,000
09/26	153	470,000
09/30	89	268,000
10/03	176	531,000
10/06	89	265,000
Total	639	1,928,000
	1984	
09/19	180	496,000
09/25	309	885,000
09/28	167	464,000
10/01	187	513,000
10/04	109	312,000
10/08	117	350,000
10/11	104	330,000
10/18	137	416,000
Total	1,310	3,766,000

Fingerling Releases

In 1983 sockeye salmon fingerlings were transported in five individual groups; each one consisted of approximately 220,000 fingerlings. The first group was released on 22 June; the remaining four, on 23 June. The total amount of fingerlings released was 1,086,000; 15,045 (1.38%) of these were marked with a clipped left-ventral fin. The released fingerlings had a mean length and weight of 32.8 mm and 0.31 g, respectively.

The 1984 sockeye salmon fingerlings were released on 5 June in three individual loads. The average transport load was 412,000 fingerlings. The total release in 1984 was 1,237,000; 25,384 (2.05%) of these were marked with a clipped left-ventral fin. The fingerlings averaged 35.1 mm in length and 0.4 g in weight.

Pathology Sampling

Pathology samples were collected during the smolt migration in 1983 and 1984. From 12 to 30 June 1983, 94 moribund or dead sockeye salmon smolts were collected; 18 smolts (19%) were IHN positive. In the spring of 1984, we collected 47 moribund or dead sockeye salmon smolts; 25 of these (53.2%) had IHN virus. In addition to collecting moribund or dead smolts in 1984, 181 normal-appearing sockeye salmon smolts were collected; four of these smolts (2.2%) were IHN positive. The percent composition of moribund and dead sockeye salmon smolts counted at the site was 0.2% for both 1983 and 1984.

In 1983 a total of 71 adult sockeye salmon females were sampled for presence of IHN virus; 19 fish (26.8%) were IHN positive. Adults sampled in 1984 had not been processed at the time of this report.

DISCUSSION

The Hidden Lake enhancement project has been very successful. The largest hatchery release of sockeye salmon fingerlings (1.2 million) in 1983 also had the highest survival rate to age-1.0 smolts: 22.4% (Appendix Table E). The survival rate of smolts to adult escapement (wild and hatchery) also appears excellent, with an average value from 1974 to 1980 of 15.6% (Table 6); this represents about three times (3X) the average survival rate of sockeye salmon smolts to adults (4.6%) at Babine Lake, Canada from 1961 to 1977 (McDonald and Hume 1984). It is not possible to accurately determine the smolt-to-adult survival; however, based on mean exploitation rates in the Cook Inlet commercial fishery, we estimate that total survival (catch plus escapement) of Hidden Lake sockeye salmon smolts ranges from 35% to 40%.

The high survival rates of sockeye salmon fingerlings are best explained by the good growth obtained during their residence at Hidden Lake. These smolts are some of the largest produced from any system in Alaska (Kyle et al. 1980). The high productive qualities of Hidden Lake and the low levels of rearing juvenile sockeye salmon allowed the 1984 smolts to reach an average length and weight of 143.7 mm and 28.7 g, respectively. This large size may give the smolts a survival advantage during their migration to pelagic feeding areas (Kelly 1937; Ricker 1962; Burgner 1962).

It is possible that the Hidden Lake stock is not exploited in the same proportion as other stocks in the Kenai River; however, in 1984 the ADF&G, Commercial Fisheries Division staff tagged 193 adult sockeye salmon at the sonar site (31.4 km) to obtain information on run-timing migration and spawner distribution. Adults were marked with floy tags from 5 to 21 July. Of these 193 floy-tagged adults, 26 were recovered at the Hidden Lake weir site from 16 July to 11 August. The shortest time for a Hidden Lake

Table 6. Hidden Lake sockeye salmon smolt and adult production, 1974-1983[a/].

Brood year	Smolts	Adults			Total[b/] adults in escapement	Survival smolt to adult escapement (%)
		Age 4	Age 5	Age 6		
1974	29,612	4,087	547	0	4,634	15.6
1975	28,212	5,192	329	16	5,537	19.6
1976	112,543	25,180	3,491	0	28,794	25.6
1977	37,665	12,369	2,976	0	17,184	19.6
1978	76,803	6,716	1,503	28	8,247	10.7
1979	161,943	1,794	1,281	0	11,075	6.8
1980	235,362	26,357	N.D.	N.D.	26,357	11.2

a/ Includes hatchery-produced fish.

b/ Includes a few age-3 adults.

adult sockeye salmon to travel the 74.9 km to Hidden Creek was 5 days, and the longest travel time was 25 days. The average travel time was 11.2 days, which converts to a migration rate of 6.8 km/day. This study indicates that the Hidden Lake broodstock escapement was mixed with that of other stocks and, thus, was accessible to the fishery.

Our information indicates that the rearing capacity of Hidden Lake for sockeye salmon juveniles is underutilized: the estimated potential capacity is from 13.5 to 15 million fish (Kyle 1976; Kyle et al. 1980). The basis for this calculation is the standing crop of zooplankton available for fingerling growth. The level of stocking in 1983 did not appear to affect the growth of the 420,000 sockeye salmon smolt migrants because they were among the largest smolts that had ever been observed. The FRED Division plans to continue its program of progressive stocking of sockeye salmon fingerlings into Hidden Lake. In 1985 approximately 2.2 million fingerlings will be stocked. The spawning-operation goal in 1985 is to collect 6.0 million eggs, which should result in about 4.5 to 5.0 million sockeye salmon fingerlings for stocking in 1986. We plan to continue the evaluation project that includes monitoring smolt and adult migrations as well as limnological conditions (including zooplankton) in Hidden Lake. The future enhancement program will be guided by our findings.

ACKNOWLEDGMENTS

We are grateful to John McDonell, David Westerman, and Robert Knight from the Kenai Wildlife Refuge staff for their long hours of dedicated field work. Thanks to Kit Rawson for biometric assistance with this report. Thanks also to Bill Hauser and Ken Leon for technical review and comments and Sid Morgan for editorial assistance.

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APPENDIX

LIST OF APPENDIX TABLES

Appendix Table A. Historical sockeye salmon escapements to Hidden Lake, 1947-1984.

Year	Escapement count*
1947	1,200
1948	1,000
1949	
1950	800
1951	
1952	2,500
1953	2,300
1954	1,500
1955	1,500
1956	1,500
1957	1,700
1958	200
1959	2,500
1960	2,200
1961	3,600
1962	800
1963	3,700
1964	2,500
1965	800
1966	
1967	
1968	600
1969	500
1970	300
1971	1,950
1972	4,950
1973	700
1974	1,200
1975	1,400
1976	4,860
1977	1,055
1978	4,647
1979	5,762
1980	27,448
1981	15,939
1982	9,790
1983	11,297
1984	27,832

*Data provided by the ADF&G, Division of Commercial Fisheries. All counts were estimated from lake and/or outlet surveys except 1971-1973 and 1976-1984, which were weir counts.

Appendix Table B. Summary of sockeye salmon egg takes and fingerling releases at Hidden Lake, 1976-1984.

Year	Egg take	Number of females	Fecundity	Number of fry released	Survival egg to fry (%)
1976	833,000	274	3,091[1]	330,000	39.6
1977	299,000	84	3,515[1]	212,000[2]	70.8
1978	312,000	100	3,118	8,000	2.7
1979	--	--	--	--	--
1980	--	--	--	--	--
1981	--	--	--	--	--
1982	1,579,000	576	2,741	1,085,000	68.7
1983	1,928,000	639	3,017	1,237,000	64.2
1984	3,766,000	1,310	2,875	1,806,000	48.0

[1] Averaged fecundity of each day's egg take.

[2] These figures excluded the residual stock taken; 107,750 residual eggs taken and 89,247 residual fry released.

Appendix Table C. Summary of infectious hematopoietic necrosis (IHN) sampling and incidence at Hidden Lake, 1976-1984.

Year	Escapement	Sample size	Percent incidence
	Sockeye Salmon Adults		
1976	4,860	51	84.3
1977	1,055	52	73.1
1978	4,647	--	--[a]
1979	5,762	--	--[b]
1980	27,448	61	69.0
1981	15,939	59	80.0
1982	9,790	60	100.0
1983	11,297	71	26.8
1984	27,832		

Year	Outmigration	Number of dead or moribund[1]	Percent incidence
1976	29,638	--	--[b]
1977	20,870	--	--[c]
1978	111,466	--	--[c]
1979	94,347	--	--[c]
1980	81,748	2,011	2.5
1981	161,522	1,034	0.6
1982	222,673	645	0.3
1983	235,233	534	0.2
1984	419,797	938	0.2

[a] Not sampled.
[b] A few diseased fish observed.
[c] No diseased fish observed.

[1] The number of dead or diseased smolts is the total number counted at smolt site; all were not confirmed for IHN virus.

Appendix Table D. Sockeye salmon smolt age composition and size data from 1976-1981 at Hidden Lake.

Year	Age class (%)	Number sampled	$\bar{x}$ length (mm)	S.D.	$\bar{x}$ weight (g)	S.D.	Total smolts
			Age 1.0				
1976	80.0	418	130.0	N.D.	N.D.	N.D.	23,711
1977	83.0	661	144.0	N.D.	N.D.	N.D.	14,843
1978	88.1	1,122	133.1	10.1	22.4	6.7	100,765
1979	84.6	973	145.1	13.1	30.7	9.8	80,006
1980	90.4	719	142.9	13.2	27.3	5.2	73,900
1981	98.2	670	143.5	9.0	28.5	5.5	158,619
1982	98.5	597	144.5	12.2	27.3	9.8	219,352
1983	93.5	264	132.0	9.8	21.3	4.9	219,708
1984	94.9	551	143.7	7.0	28.7	4.7	398,387
			Age 2.0				
1976	20.0	106	146.0	N.D.	N.D.	N.D.	5,928
1977	16.0	130	199.0	N.D.	N.D.	N.D.	2,827
1978	9.6	122	189.8	56.3	79.3	66.3	10,701
1979	15.2	175	177.0	19.7	57.2	20.4	14,341
1980	9.6	76	199.6	31.9	83.9	39.6	7,848
1981	1.8	73	197.8	27.6	81.4	37.4	2,903
1982	1.5	31	173.8	31.3	55.3	36.5	3,321
1983	6.6	78	185.5	54.8	66.1	62.7	15,525
1984	5.0	58	169.6	22.9	49.2	19.8	20,989

Appendix Table E. Estimated survival and contribution of hatchery-stocked sockeye salmon fingerlings at Hidden Lake.

Year	Sockeye fingerlings released	Total age-1.0 smolts[1]	Age-1.0 hatchery smolts[1]	Fingerling to age-1.0 survival (%)	Hatchery contribution (%)	Hatchery adult escapement[2]	Escapement / Smolt-to-adult survival (%)	Total Return[3] / Smolt-to-adult survival (%)	Hatchery contribution[4] (%)
1977	330,200	98,200	58,700	17.8	59.8	11,550	19.7	39.4	41.0
1978	301,100	79,800	47,500	15.8	59.5	5,100	10.7	21.4	27.1
1983	1,085,300	393,400	243,500	22.4	58.0				
1984	1,236,900	396,000	298,000	24.1	75.0				

[1] Year following fingerling release.
[2] Includes age-4 (2 ocean) and age-5 (3 ocean) returns.
[3] Assumes 50% interception by commercial fishery.
[4] To age-2 ocean return.

Appendix Table F. Hidden Lake sockeye salmon smolt outmigration and adult escapement.

Year	Smolt outmigration	Percent hatchery	Adult escapement
1976	29,638	--	4,860
1977	20,870	--	1,055
1978	111,466	59.8	4,647
1979	94,347	50.3	5,762
1980	81,748	--	27,448
1981	161,522	--	15,939
1982	222,673	--	9,790
1983	235,233	--	11,297
1984	419,797	61.0	27,832
1985	396,000	75.0	25,000